

EPA-1530

"Christopher Elliott"
<USCEL@icopal.com>
03/15/2012 03:02 PM

To Phil North
cc
bcc
Subject Re: Teranap - Life Expectancy

2 attachments



Longevity of Bitumen.pdf The Radioactive Waste Management Program in France.pdf

Phil,

Anything outside of what I sent you would be my own personal opinion. Which does not reflect the opinion/beliefs of Siplast/Icopal or anyone else within the company.

If it's buried, eliminating all the external factors that contribute to the aging of bituminous geomembrane (i.e. heat, UV, oxidation, etc) I can't see why it wouldn't last forever. Please see attached documents, for the basis of my opinion. From the previous document I had sent to you, if there is minimal loss in the mechanical properties of the product with only a few inches of sediment... in the right application, and installed properly I am very confident in Teranap.

(See attached file: Longevity of Bitumen.pdf)(See attached file: The Radioactive Waste Management Program in France.pdf)

Best regards,

Christopher Elliott
Siplast - Calgary
uscel@icopal.com
tf: 1.800.922.8801 ext 2369
c: 403.612.8488
o: 403.719.7876

▼ Phil North ---03/15/2012 10:51:31 AM---Hi Christopher, I understand the reluctance to quote any number absent specific

From:	Phil North <North.Phil@epamail.epa.gov>
To:	"Christopher Elliott" <USCEL@icopal.com> ,
Date:	03/15/2012 10:51 AM
Subject:	Re: Teranap - Life Expectancy

Hi Christopher,

I understand the reluctance to quote any number absent specific installation circumstances. But can you give me a ball park life expectancy to work with - decades (a few, several)? Centuries (a few, several, forever)?

Phil

Phillip North
Environmental Protection Agency
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"To protect your rivers, protect your mountains."

From: "Christopher Elliott" <USCEL@icopal.com>
To: Phil North/R10/USEPA/US@EPA
Date: 03/14/2012 01:45 PM
Subject: Teranap - Life Expectancy

Phil,

Thank you for returning my call earlier today. As promised, please find attached some further information on the life expectancy of our bituminous geomembrane. This should provide a realistic understanding of how well the membrane will hold up in a real world exposed application.

You were mentioning that there was a project where they were potentially considering using a bituminous liner for a tailings facility in Alaska. Would you be able to tell me the name of the projects and which firms are looking after the design?

Enjoy the rest of your week.

(See attached file: Casper Alcova RTD Report June 29 2011.pdf)(See attached file: Casper Alcova Commentary July 2011.pdf)

Best regards,

Christopher Elliott
Siplast - Calgary
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[attachment "Casper Alcova RTD Report June 29 2011.pdf" deleted by Phil North/R10/USEPA/US] [attachment "Casper Alcova Commentary July 2011.pdf" deleted by Phil North/R10/USEPA/US]

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BNL-NUREG--38999

ABSTRACT

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An estimate of the rate of biodegradation of bituminous material is necessary to predict the long-term stability of low- and intermediate-level waste solidified using bitumen. Data from a series of scoping experiments have been analyzed to determine the rate of degradation of blown bitumen samples under a variety of conditions. Among the variables investigated were the effect of soil type, moisture, sample surface area and microbial strain. The rate of degradation was measured by monitoring metabolic CO_2 release. Using this data it was found that, for degradation in soil, a mean rate of 5.5×10^{-4} cm/yr represented all data to within a factor of about two. This mean rate is nearly that for distilled bitumen samples measured by other workers.

INTRODUCTION

Bituminous materials are being used or have been proposed for use for the solidification of low- and intermediate-level wastes (see, for example, [1,2,3]). Because it is a hydrocarbon-based material, bitumen may be more susceptible to biological degradation when compared to other materials commonly used as solidification agents, e.g., cement.[8] A number of reports discuss the biodegradation of bitumen and tar. These include general summaries of the biodegradability of the material [4,5] as well as specific studies which quantify the susceptibility of bitumen toward microbial degradation by measuring the growth of cultures [2,3,6,7,8]. In addition, rate data have been obtained [7,9]. The qualitative aspects of these studies indicate the following:

1. Microbial attack of bitumen is most likely to occur under aerobic conditions.
2. Degradation can occur under varying conditions of available water.
3. A large number of bacterial and fungal strains are capable of degrading bitumen.
4. The various fractions in bitumen appear to degrade at different rates.
5. Degradation of bitumen is expected to result in the generation of gases (H_2 , CH_4 , CO_2 and H_2S) and organic liquids.
6. There is little or no effect on the release of radionuclides due to microbial attack of bituminous waste.

Under 10 CFR Part 61, Class B and C waste must remain stable for a minimum period of 300 years. The concept of stability (defined as structural stability) requires resistance to the stresses that the disposal site places upon the waste, including microbial attack. Testing methods and acceptance criteria which have been recommended to demonstrate stability are described in the Technical Position on Waste Form (TP) [10]. The TP recommends that two culture growth tests, ASTM G21 and ASTM G22, be run to demonstrate resistance to microbial attack. For those waste forms which

*Experimental work carried out under the auspices of the U.S. Nuclear Regulatory Commission.

MASTER

exhibit susceptibility in the ASTM tests, further testing to determine the rate of degradation is recommended. This test determines the rate of degradation by measuring the rate of CO₂ evolution from small sample forms using a method developed by Bartha and Pramer [11].

In order to better define the conditions of the Bartha-Pramer test recommended in the TP and to determine the effects of soil type, moisture, temperature and sample size on test results, the NRC sponsored a series of tests. The data resulting from these tests has been published by Bowerman et al. [9]. However, the treatment of the data presented in Reference 9 was such that only qualitative statements could be made concerning the effects of the parameters mentioned above. This data has been analyzed to determine the rate of degradation of blown bitumen as well as an estimate of the uncertainty in this rate for each set of experimental conditions. Using the results of this analysis, it is possible to make general statements about some of the factors affecting the rate of degradation of bitumen as well as to indicate directions for additional work in this area.

EXPERIMENTAL

The details of the experimental procedure are given in Bowerman et al. [9] and are summarized here. A list of experimental conditions is given in Table I.

Table I. Experimental conditions for degradation experiments. Samples consisted of 4 nominal 1-cm x 1-cm-sized cylinders except where noted.

Expt. No.	Medium	Microbe	Surface Area (cm ²)	Pre-test Moisture (Weight Percent)	Length of Test (days)
1	Barnwell soil	gen. soil	30 + 3	2.6 + -	177
2	Upton soil	gen. soil	30 + 3	5.1 + 2.6	197
3	Upton soil	Pseudomonas	30 + 3	5.1 + 2.6	35
4	Richland soil	gen. soil	30 + 3	5.2 + 0.3	197
5	Barnwell soil	gen. soil	30 + 3	5.6 + 0.2	196
6	Barnwell soil	gen. soil	30 + 3	18.3 + 0.4	181
7	Barnwell soil	gen. soil	20 + 2 ^a	5.6 + 0.2	192
8	Barnwell soil	gen. soil	134 + 13 ^b	5.6 + 0.2	206
9	agar	Pseudomonas	30 + 3	- + -	54
10	agar	fungi	30 + 3	- + -	59

^aNominal 2-cm x 2-cm cylinder.

^b1-mm-thick sheet.

A blown bitumen (PIONEER 221 density = 1.01 g/cc) was used in these tests. It was fabricated into three shapes:

1. Right circular cylinders of nominal diameter and height of 2 cm (2 x 2),
2. Right circular cylinders of nominal diameter and height of 1 cm (1 x 1),
3. Sheets approximately 1 mm thick.

The samples for each experiment were obtained by taking approximately 7 grams of one of the three sample types. Thus, for each experiment, the volume of material was constant while the surface area varied depending on the type of sample used. For 2 x 2 samples, the surface area was approximately 20 cm² and one form was used. For 1 x 1 samples, four forms were used and the surface area was approximately 30 cm². Finally, the 1-mm sheet samples had a surface area of about 130 cm². It is estimated that the variation in the surface area for each of the sample types was approximately 10%.

Two growth media were used in these experiments, soil and nutrient agar. Three types of soil were used. Two were backfill soils obtained from the low level waste disposal sites at Barnwell, SC and Richland, WA. These soils have been characterized previously [12]. The third was a surface soil sample obtained at BNL. It has not been extensively characterized. All soils were used in their field moist condition (see Table 1). In addition, for two experiments on Barnwell soil, conditions of full saturation and one half field moist were used. The nutrient salts agar medium supplied all essential nutrients except a source of carbon.

For most of the soil experiments, the indigenous soil microbes were used. In the single exception (Experiment 3), the soil was sterilized by gamma radiation and inoculated with Pseudomonas aeruginosa. For the two sets of experiments run in agar, inoculation was with either the mixed fungal culture perscribed in ATSM G21 or with Pseudomonas aeruginosa which is perscribed in ASTM G22.

The experimental procedure was as follows. Bitumen samples were loaded into the Bartha-Pramer flasks along with the medium (agar or soil). Sets of four replicates were used in each experiment. Controls consisted of growth medium plus microbe but with no bitumen. Three replicates were used for controls. Atmospheric CO₂ was excluded by means of an Ascarite filled tube. The experimental apparatus is illustrated in Figure 1. The amount of CO₂ released from controls and samples was determined by titration of the 0.1 N KOH solution in the side arm of the flask. The KOH solution was withdrawn from the flask at periodic intervals which varied over the course of each experiment and replaced with fresh solution. Each sample was titrated with standard HCl solution (either 0.5 or 0.1 N) and the incremental amount of CO₂ generated in the sample and control flasks calculated.

RESULTS AND DISCUSSION

The cumulative carbon dioxide released was determined for samples and controls by summing the incremental data. The resultant cumulative data was fit using a linear least squares regression analysis. A plot of the cumulative CO₂ released from bitumen in Richland, WA soils is shown in Figure 2 as an example (Experiment 4). The net CO₂ release rate was determined by subtracting the least squares line of the samples from that of the controls. The slope of the line (degradation rate) was then converted to units of thickness of bitumen consumed/year. These results are shown in Table 2. The variation in the rates given in this table reflect the uncertainties in the surface area measurement as well as the sample-to-sample variation in the CO₂ released by both the samples and controls.

The rate data presented in Table II provide a means to estimate the magnitude of the effects of changing conditions on the stability of bitumen. The effect of microbe type can be seen from the comparison of the rates observed in experiments 2 and 3 as well as 9 and 10. In experiment 2, microbes indigenous to the soil were present, while in experiment 3, the soil was sterilized and innoculated with a particular bacterial strain,

Pseudomonas aeruginosa. Comparison of the mean rates indicates that the indigenous soil microbes degraded the bitumen some 70% faster than the bacterial culture. Experiments 9 and 10 show the effect of a change in microbe in a nutrient salts agar. Two microbe cultures were used, a single bacterial strain (experiment 9) and a mixture of five fungal strains as specified in ASTM procedure G21. The rate observed due to attack by the fungi was significantly higher (approximately 2.5 times based upon mean values).

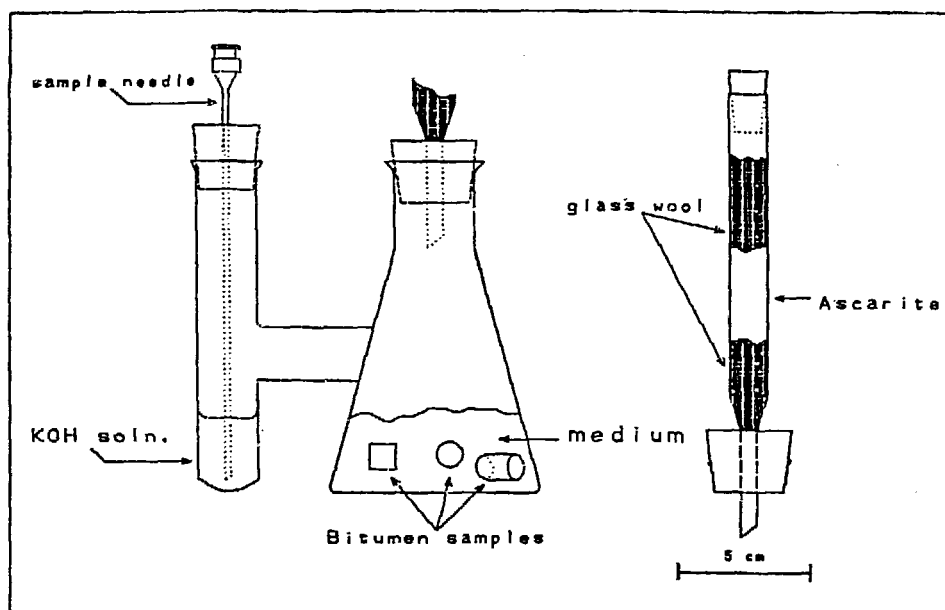


Figure 1. Experimental apparatus used in Bartha-Pramer experiments.

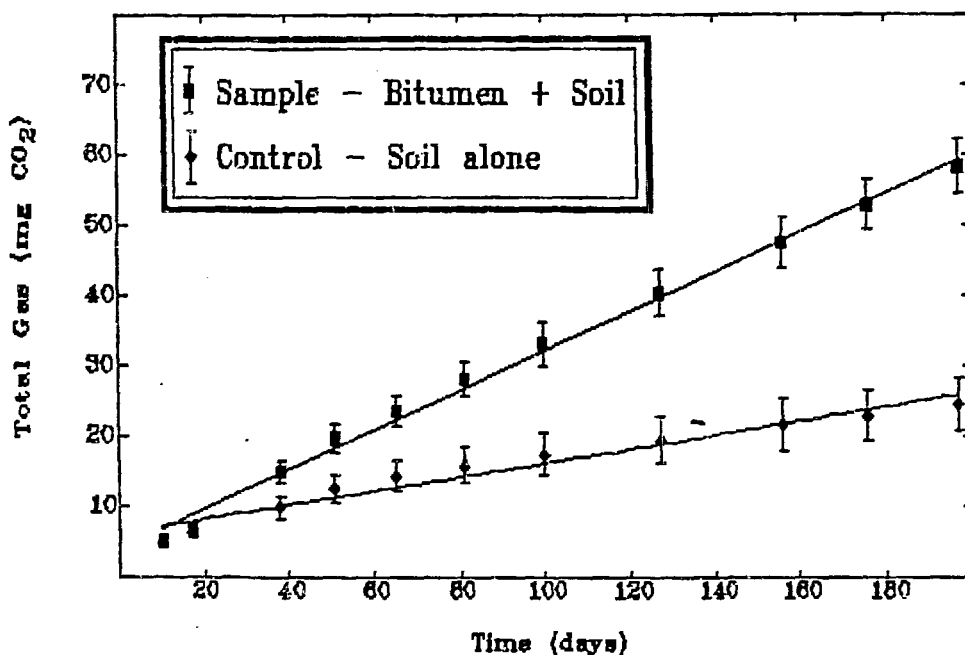


Figure 2. Cumulative CO₂ released from bitumen in Richland soils vs time.

Table II. Degradation rates of blown bitumen based on cumulative CO₂ released in modified Bartha-Pramer test. Experimental conditions are defined in Table I.

Expt. No.	Rate (cm/yr)
1	5.78E-04 ± 1.2E-04
2	3.65E-04 ± 5.6E-05
3	2.11E-04 ± 1.4E-04
4	5.96E-04 ± 2.5E-04
5	1.05E-03 ± 1.3E-04
6	4.58E-04 ± 8.1E-05
7	6.37E-04 ± 1.6E-04
8	5.43E-04 ± 6.5E-05
9	2.44E-03 ± 4.1E-04
10	5.56E-03 ± 6.2E-04

Similarly, the effect of the growth medium is seen by comparison of those studies done in nutrient salts agar (experiments 9 and 10) with those conducted in soil. The agar represents an idealized growth medium in which all nutrients except a carbon source are provided by the medium. Comparison of the observed mean degradation rates given in Table II shows that the lowest rate in agar is 2.3 times higher than the highest rate seen in soil. These differences are magnified when experiments 3 and 9 are compared. The sole difference in these experiments was the growth medium. In both experiments the microbial population was the same, namely, a single strain of bacteria. The mean rates in these experiments varied by almost an order of magnitude. The rate in soil was lower.

Considering the wide range in experimental conditions, the observed variation in the rate of degradation is surprisingly small. For example, with the exception of the Barnwell 1 x 1 samples at 5.6% initial soil moisture (see below), Figure 3 shows almost no variation of the observed rate with initial soil moisture. For all experiments conducted in soil (experiments 1 through 8), the mean degradation rate is plotted versus initial soil moisture in Figure 3. The average of these degradation rates was $(5.5 \pm 2.3) \times 10^{-4}$ cm/yr. This rate would result in about a 1% volume change in a 55-gallon drum of bitumen over 300 years. Further, the average rate observed for blown bitumen compares favorably with the rate measured on blocks of distilled bitumen containing simulated NaNO₃ waste measured by Abdellah and Pederson of 6×10^{-4} cm/yr [7].

Figure 3 also illustrates the variation which can be expected in the observed degradation rate as a function of sample size. The rates plotted in this Figure are normalized to a unit surface area. Thus, one would expect that all the degradation rates observed for bitumen in Barnwell soil at 5.6% initial soil moisture would be the same if the degradative process is controlled by the surface area of the bitumen. It can be seen from the figure that the data for the sheets of bitumen and the 2 x 2 samples are the same within experimental error. The rate observed for the 1 x 1 samples under field moist conditions are significantly higher. The reason for this different rate is unknown.

CONCLUSION

The results of these experiments indicate that environmental factors

studied here have a surprisingly small effect on the rate of biodegradation of bitumen as measured by CO_2 generation. One limitation of this technique is that the effects of biodegradation on samples are only measured indirectly. Further, anaerobic degradation accompanied by the evolution of CH_4 is not measured at all. While this test provides a useful means for estimating degradation rates for regulatory purposes, additional work to correlate the generation of carbon dioxide with long-term waste form performance would be useful. More importantly, the biodegradation rate of bitumen containing actual or simulated radwaste should be measured to determine if the effect of these additives is to enhance or inhibit the degradation rate. In the absence of such waste form specific and disposal site specific data, however, the results of these tests indicate that it may be possible to bound the performance of more prototypic samples through short-term, generic tests.

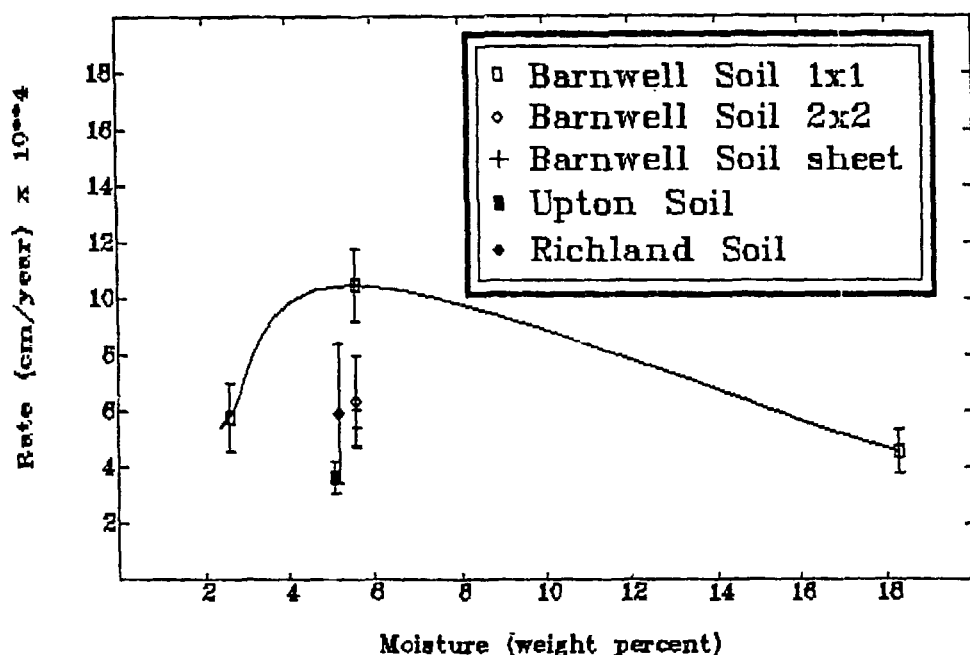


Figure 3. Mean degradation rate of bitumen in various types of soil versus initial soil moisture. Data connected by spline fit represents bitumen samples in Barnwell soil in which the soil moisture content has been intentionally varied.

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Author's name _____

Page _____ of _____

THE RADIOACTIVE WASTE MANAGEMENT PROGRAM IN FRANCE

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SUMMARY

For every category of waste, from very low level (VLL) to high level and long lived (HVL) waste, ANDRA, the French national agency for radioactive waste management, is responsible for proposing suitable disposal solutions.

For low and intermediate level, short lived waste, engineered solutions have been implemented for many years. Centre de la Manche, opened in 1969, is a near-surface disposal facility now entering into its institutional control period. With this experience of 25 years, ANDRA has designed, built and, since 1992, has been operating the Centre de l'Aube disposal facility, offering a volume capacity of 1 000 000 m³ (about twice that of Centre de la Manche). This capacity covers the French needs for more than 50 years.

For other categories of waste, ANDRA is performing investigations. In particular, for VLL, ANDRA has developed a disposal design which has been submitted to waste generators and safety authorities. A site could be selected during 1999.

High-level waste strategy is governed by the waste act, issued on December 30, 1991 which defined three research areas to be intensively investigated. These areas include :

- Partitioning and transmutation,
- Deep geological disposal through the construction of underground laboratories,
- Long term interim storage.

The second option comes under ANDRA's responsibility and the two others under the French Atomic Energy Commission.

At the present time, three sites have been investigated, public inquiries have been held and favourable votes of local community's representatives have been registered. The applications for constructing and operating underground laboratories on these three sites were submitted to Government at the end of 1996. On 9 December 1998, the French Government decided the construction of two laboratories, in accordance with the law of 30 December 1991 : the first one on the East site at Bure and the second one on a new granitic site that ANDRA has to find.

An overall assessment report related to the results obtained for the three research areas will be presented to Government in 2006.

INTRODUCTION

On December 30, 1991, the law which represents the basic framework for radioactive waste management was enacted in France. It entrusted ANDRA, the French national agency for radioactive waste management, with the responsibility for proposing suitable disposal systems for every category of waste.

Radioactive waste management systems must be commensurate with the risks involved, which is gauged by two parameters : the activity level and the half-life. Table 1 presents the status of the waste classification and the related choices for their management.

Table 1 : Status of disposal systems according to the radioactive waste classification

ACTIVITY LEVEL	HALF - LIFE	
	Short (T < 30 y)	Long (T > 30 y)
Very low	Under study	
Low	Surface disposal	Under consideration
Intermediate	Surface disposal	Law issued on 12/30/91
High	Law issued on 12/30/91	Law issued on 12/30/91

VERY LOW-LEVEL WASTE

The specific activity of the very low-level waste (VLL) is less than 100 Bq/g, with an average of 10 Bq/g and returns to the natural radioactivity level in a few decades. Although this activity may appear very low compared with the other waste categories, the guideline is to set up management systems developed on an individual case basis and adapted to the characteristics of each waste category and in particular of VLL waste. In France, no activity limit has been fixed below which the waste issued from nuclear facilities could be considered as a non-radioactive one.

VLL radioactive waste comes from two origins :

- nuclear industry, following the dismantling of nuclear power plants, research centers and fuel cycle plants,
- conventional industries such as chemical, involving metallurgy using ores containing traces of natural radioactivity.

More than 90 % of VLL consists of inert materials, rubble, scrap iron, with some thermal insulation and technological waste, with virtually no chemical toxicity.

The average radiological spectrum includes the following radionuclides (^{54}Mn , ^{58}Co , ^{60}Co , ^{63}Ni , ^{90}Sr , ^{234}U , ^{238}U). Other radionuclides such as ^3H , ^{65}Zn and ^{134}Cs may be present in traces.

The reasons underlying the creation of a specific disposal facility are, in one hand, a precautionary principle which requests that VLL waste management be conducted with rigor, in a regulatory framework and with substantial monitoring, and in the other hand, the principle of economic optimization.

The disposal concept is based on two independent barriers. The first one is composed of a top geomembrane, which prevents water from infiltrating into the waste and a bottom geomembrane. The waste is therefore kept dry. Leak tests are performed by a drainage layer placed at the base of the waste and a test sump.

The first barrier must procure a perfect seal for several decades. The second barrier consists of natural clay. Tightness under the facility is provided by a layer at least 5 m thick and by a capping system employing the same material. The overall system ensuring the containment module must guarantee long-term retention.

These two first components making up the containment module are supplemented by the rest of the geological environment, consisting of the clay layer outside the module and the aquifer.

The disposal facility would be monitored at three levels : in the trenches, inside the facility perimeter (rainwater, air, gamma exposure, aquifer), outside the facility.

The waste is placed in batches in layers about 1 m deep and stabilised by sand to fill the voids and to prepare the base for the next layer. A trench drainage system collects any water in a sump surmounted by a manhole accessible from the capping.

A geomembrane welded to the previous one guarantees upper tightness. It is surmounted by a drainage system which removes the water, a clay layer and a backfilling material consisting of clay and topsoil.

Excavation and trench preparation operations are conducted at the production rate. All disposal operations are performed under a roof covering all the pairs of trenches in operation.

The surveillance phase is estimated at thirty years after operations are terminated. These measures are aimed to check the absence of dissemination of radioactive materials and to confirm compliance with the regulations governing this type of waste.

Figure 1 shows French VLLW disposal concept.

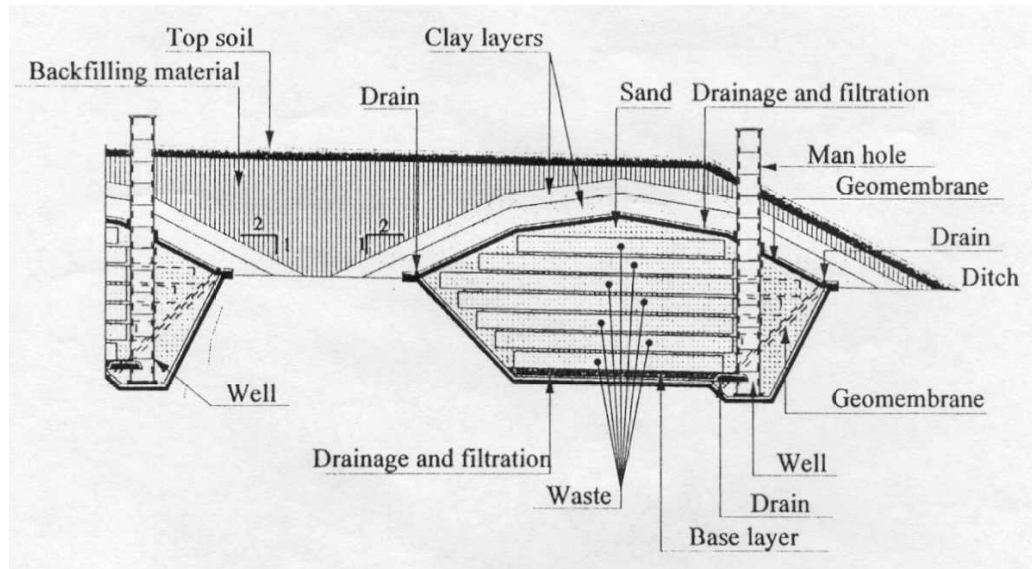


Fig. 1 : VLLW disposal concept

LOW AND INTERMEDIATE LEVEL, SHORT LIVED WASTE

Unlike VLL waste, low- and intermediate-level short-lived waste requires industrial operations before disposal. The first facility (Centre de la Manche) was commissioned in June 1969 in the commune of Digulleville. After accommodating more than 500 000 m³ of radioactive waste, it was closed in July 1994. Since then, the final cap has been installed. It consists of a multiple layer complex which comprises, starting from the base of the cap :

- a bottom layer of schistose material designated to create the basic slope of the disposal cap and contribute to the imperviousness of the cover
- a drainage layer made of fine-grain sand to collect water beneath the bituminous geotextile,
- a bituminous geomembrane made of a bitumen saturated geotextile,
- another drainage layer made of fine-grain,
- a semi-impermeable layer of schist to minimize the amount of water infiltration and to protect the membrane against root systems and burrowing animals,
- a layer of topsoil to promote grass growth.

Water recovered from the cap is collected in networks surrounding the site. Runoff water is separated from infiltration water by, on one hand, a system of large pipes for surface water located underneath the site perimeter road and a system of smaller pipes for infiltration water drained from the cap.

The administrative formalities for closure and transition to the institutional control period are under way. The procedure involves the examination of the technical files and safety assessment report prepared by ANDRA.

The Centre de la Manche disposal facility was relayed in 1992 by the Centre de l'Aube, which was subjected to intensive geological investigations before the site was selected. It is built on an Aptian sand, which itself overlies an impervious clay layer. Hence, it is distinguished by a relatively simple hydrogeological system, with a well-known outlet.

The disposal concept of the Centre de l'Aube is based on a multiple-barrier system, including the

package, the disposal structures and the geological environment. The packages play the role of blocking the radioactive materials and preventing their dispersion. All the waste is mixed with an immobilization material (concrete, grout, resin, bitumen) in concrete or steel containers. Figure 2 shows Centre de l'Aube facility.



Fig. 2 : The Centre de l'Aube disposal facility

As in the Centre de la Manche, a piezometric network is used to monitor the aquifers on and around the site. The results of the analyses performed on samplings are published regularly and communicated to the local administration and population.

Its capacity of one million m³ is designed to accommodate low-level, short lived waste generated until around 2040. In the interest of optimizing the long-term disposal, both technologically and economically, ANDRA and the waste generators have jointly developed an integrated waste management system that covers all phases of waste processing, transportation and disposal, pursuant to regulations. The cornerstone is a comprehensive quality assurance program, yet it remains flexible enough to accommodate special cases.

ANDRA issued technical specifications that require waste generators to submit a waste acceptance file on each type of package they plan to produce for ANDRA's approval.

The second major component of the integrated waste management system involves tracking the waste from the moment it is generated through its final disposal. ANDRA sets up a computer network link between waste generators, disposal facility and its own headquarters in this purpose.

HIGH-LEVEL AND LONG-LIVED WASTE

High-level and long-lived radioactive waste comes mainly from nuclear power plants. For countries, as France, which reprocess the spent fuel to recover the uranium and the plutonium from the irradiated fuel, the main waste stream appears at this step. It consists, firstly, with the fission products and minor actinides stabilized in a glass matrix by the French vitrification process. It is, secondly, constituted with the structures remaining after dissolution of the fuel : hulls and end

pieces, mainly of zircaloy, which are compacted and, finally, different technological waste which are compacted, cemented or bitumized. Activity is chiefly due to small quantities of fission products, long-lived actinides and activation products. High level and long-lived waste could also be partly some unprocessed fuels.

Spent fuels and vitrified waste are classified as C waste. Hulls, technological waste and bitumized sludge are classified as B waste.

C waste have high specific activity, which results in a very high thermal load, at least for several hundred years, until the high activity mainly due to ^{90}Sr and ^{137}Cs , with half-lives close to thirty years, have decayed. B and C waste contain relatively large amounts of very long-lived radionuclides (^{239}Pu , ^{237}Np , etc).

The first investigations to dispose B and C waste in a deep geological repository were started in France in the early 1980s. A research program on sites in four different geological formations (granite, clay, salt, shale) came up against opposition from the local population. After a moratorium declared in 1990 by the Prime Minister, and following the surveys conducted independently for the Government and the Parliamentary Office for Scientific and Technological Decisions, a bill was presented to the French Parliament. The law passed on 30 December 1991 sets the research framework.

On the one hand, it opens up the programs to the assessment of the different management systems, demanding research in three areas :

- separation and transmutation of the long-lived radionuclides present in the waste,
- reversible or irreversible disposal of the waste in a deep geological formation, particularly through the construction of underground laboratories,
- conditioning and long-term storage of the waste.

The law of 30 December 1991 presents several other characteristics of a new approach of rad-waste management. It provides for fifteen years of research without any industrial decision on geological disposal. In this framework, the underground laboratories, built to study the in situ rock properties, cannot be transformed into a disposal, even if these properties are very favorable, by technical factors alone. The Parliament has to debate and pass a new law in 2006, after examining the results of the three research alternatives to decide on further action on research and, subsequently, the creation of a disposal facility.

To obtain precise and also comprehensible scientific information, the law of 30 December 1991 set up a National Evaluation Commission (NEC) composed of eminent scientists :

- six qualified personalities, including at least two international experts, designated equally by the National Assembly and the Senate, on the proposal of the Parliamentary Office for Evaluating Scientific and Technological Alternatives,
- two qualified personalities designated by the Government on the proposal of the Supreme Council for Nuclear Safety and Information,
- four scientific experts designated by the Government on the proposal of the French Academy of Sciences.

This Commission will be charged with preparing an annual report on the state of progress of research in the three directions, and on the progress achieved abroad in the area. It will be required to prepare the final summary report of 2006 on which the Parliament will have to debate.

Studies under way on separation and transmutation, and also on waste conditioning and long-term interim storage, are coordinated by the French Atomic Energy Commission (CEA). Studies conducted on waste disposal in geological repositories are coordinated by ANDRA.

In the spirit of the law, a new approach is decided by the Government for siting an underground research laboratories has to be conducted. Among all the French locations favorable to a geological repository, the choice is made on the basis of representations by the territorial authorities (municipal, departmental and regional councils) which votes to host such a laboratory.

To seek such a local consensus, in late 1992, the Government charges a member of the National Assembly, Christian Bataille, already the reporter to the Assembly on the law of 30 December 1991, with a *mediation* mission. The *mediator* is asked to examine the situation in some thirty Départements, including eight which volunteered to receive him. Four of them, the Haute Marne, Meuse, Vienne and Gard, finally declare their candidacy with the virtual unanimous support of their local elements.

In January 1994, the Government authorizes ANDRA to initiate preliminary surveys accordingly. Rapidly, Haute Marne and Meuse sites merge under the same one, at their frontier, known as East site.

Seeking the involvement of the local players, the law promotes also openness and transparency. The annual reports of the NEC are made public. Besides, on each prospecting and subsequently underground laboratory site, a Local Information Committee (LIC) is formed, provided with operating and investigative resources. It includes State representatives, elected territorial officials, members of environmental protection associations, members of farm unions, representatives of professional associations, personnel connected with the site, and ANDRA. According to the law, the LIC is informed about the nature and progress of the work, as well as the results. It can be consulted on any matter pertaining to the operations of the underground laboratory which have any effect on the environment and the neighborhood. It can have hearings conducted as well as second analyses by approved laboratories.

And finally, according to the law, a financial help to the economic development of the departments favorable to the construction of an underground laboratory is set in place : 5 MFF/year during preliminary surveys and 60 MFF/year during the building and the operating the laboratory. After two years of surveys by surface techniques, essentially geophysical prospecting and drilling, no prohibitive factor is identified on any of the three sites, and ANDRA is authorized to compile and to file the applications for permits to install and operate an underground laboratory on each of them.

On East site, the relevant formation lies at a depth between 400 and 600 m and corresponds to Callovo-Oxfordian stage. It consists of an argillite composed of about 40 to 45% clay (interbedded illite/smectite), about 30% carbonates and 25% quartz. It is 150 million years of age and about 130 m thick.

On Vienne site, the favorable host rock identified belong to a Hercynian granitic environment. It consists of a granodiorite deposited about 350 million years ago, at 450 m depth and over a thickness of several hundred meters.

On Gard site, a favorable Cretaceous formation lies at a depth between 400 and 800 m and dips northward. It dates from the Vraconian (100 million years). This silty formation corresponds to a shallow coastal sedimentation zone where marine sediments accumulated (40% clay and 10 to 20% carbonates) together with continental debris (30 to 50% quartz), regularly mixed by animals and wave action.

The three permit applications are examined in 1997. The examinations covered :

- technical analysis by the Nuclear Installation Safety Directorate, the French safety authority ; it issues a favorable opinion to go on operations on the three sites,
- public inquiry ; the Inquiry Commissions submitted conclusions favorable to continued operations on each of the three sites,
- the vote of the local and territorial authorities, which very largely support the going on of the operations on the three sites.

The National Evaluation Commission has expressed a favorable opinion of the two clay sites but underlines some specific technical difficulties about the granite of the Vienne site, related to its confinement properties.

On 2 February 1998, the Government announces that the decision to create underground laboratories will be taken in a few months, after a supplementary report on reversibility of a repository, requested from the National Evaluation Commission. This report, transmitted to the Government in June 1998, confirms the reversibility of a repository during its operation, which becomes less and less easy with time after this phase and particularly after its closure. Consequently, it concludes that a deep geological repository fits better the immediate disposal of low and medium activity long-lived waste (B waste) than high activity ones (C vitrified waste or spent fuel). Actually, B waste are final waste, without any heat generation when C waste, and especially spent fuel, are matters which could be reprocessed in the future to recover valuable elements or, in another hand, to reduce their toxicity, depending on the scientific progresses.

Simultaneously on February 1998, a greater effort on R&D is asked to the CEA, dealing with long term storage. Particularly, a report on the concept, the interest and the feasibility of a subsurface storage center is requested from the CEA before the end of 1998. This report is transmitted to the Government at the end of November 1998.

During site characterization and in connection with rock properties, ANDRA improved disposal concepts. These concepts, after several iterations, have to be integrated to the final report of 2006 as disposal design, on which the decisions for the future strategy on the high level have to be decided and voted.

The master plan for research programs is shown in Figure 3. The main deadlines are the following:

- 1999, with the beginning of shafts drilling for the underground laboratories,
- 2001, with access to the underground laboratories and the beginning of downhole ex-

periments, which have been prepared for many years in methodological laboratories abroad,

- 2005, with submittal of the summary file for evaluation.

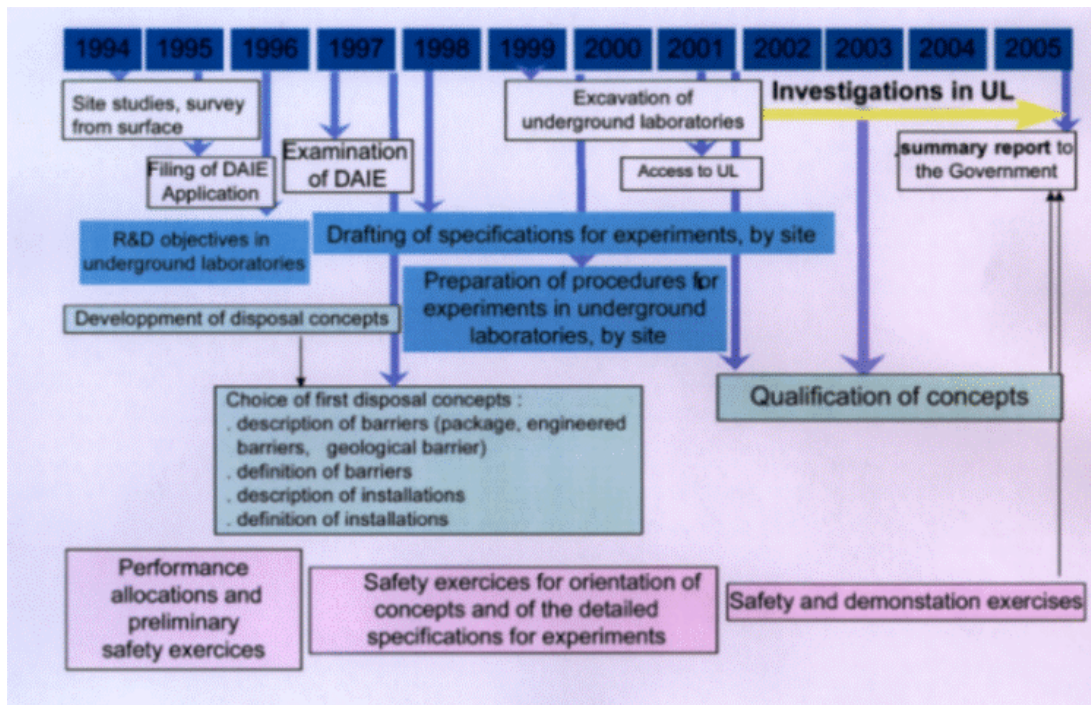


Fig. 3 : The timetable for research programs

CONCLUSION

The different types of waste produced either by the nuclear industry or by the various organizations using radioactive materials are taken into account in the management system that has been set up in France. This begins with the National Radioactive Waste Inventory, which serves to identify and locate the waste produced in the past and to list current production.

Depending on the characteristics of the waste, different appropriate systems are then proposed. These are in a preliminary stage for very low-level waste. They have reached industrial maturity for low- and intermediate-level and short-lived waste. The Manche and Aube facilities provide long-term safety guarantees for man and his environment. High-level, long-lived waste is subject to intensive research program, carried out within the specific framework set by the law of 30 December 1991, which stipulates a Parliamentary debate in 2006 to decide on the best alternative.

On 9 December 1998, the Government decided the construction of two laboratories, in accordance with the law of 30 December 1991 : the first one on the East site at Bure and the second one on a new granitic site that ANDRA has to find. The corresponding Decree of the Council of State should be published within next few months.